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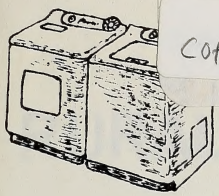
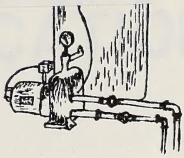
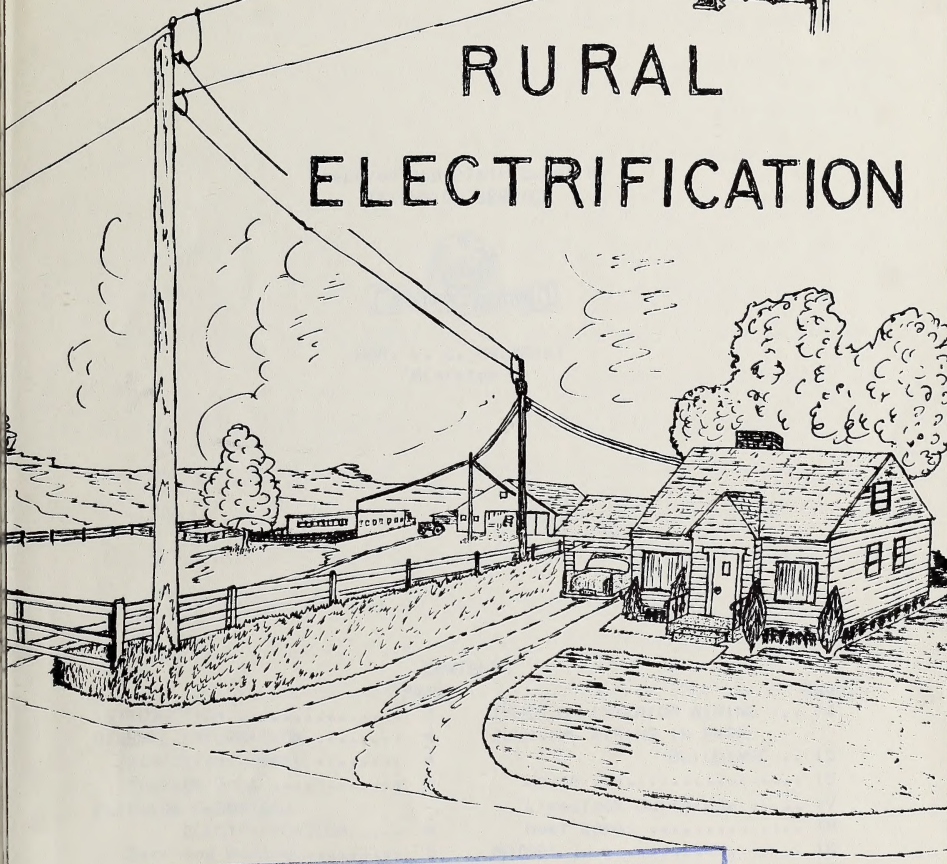




RURAL ELECTRIFICATION



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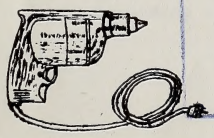

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RURAL ELECTRIFICATION

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PROVINCE OF ALBERTA
DEPARTMENT of AGRICULTURE

HON. L. C. HALMRAST
Minister

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FOREWORD

There has been a remarkable development of rural electrification in the Province in the past ten years. During this period the number of farms supplied with high line power has multiplied approximately twenty times. The extension of farm electrification will continue to expand throughout the Province.

This expansion of rural electrification has resulted in considerable interest in electrical power on the farm. The purpose of this publication is to acquaint the rural user with electrical terms and meanings, to assist in planning for the eventual use of electricity on the farm, and to familiarize the user with the various types of electrical equipment and their characteristics.

The portion on wiring is supplied to increase the understanding of wiring principles and is not intended as a detailed guide on electrical wiring installations. It is suggested that persons without experience with electricity and electrical wiring should rely on qualified electricians to install the farmstead and building wiring. Emphasis should be placed on the importance of planning the system to suit the family requirements and also allow for future electrical installations.

RURAL ELECTRIFICATION

INTRODUCTION

The connection of electric power to the farmstead is one of the major advancements in deciding the standards of living in rural areas. The uses to which it can be put are many and it also has the advantages of being clean, cheap, inconspicuous and flexible in output. However, when the farmstead is wired and the power connected, the owner and operator does not receive any instructions or a manual on operation and maintenance, as is the case with purchases of power machinery.

Electric power lies dormant in the wires, unheard and unseen, but in almost unlimited quantities ready to go to work at the flick of a switch. To learn what electricity is and how it functions would require many hours of study and demonstration. However, it is important to know how to harness and use electricity safely and efficiently.

Licensed electricians, like most tradesmen, spend several years as an apprentice learning the trade, and to keep abreast of the continued changes and advancements, must attend refresher courses and do considerable reading. An electrician is usually called upon to do the major wiring for a farmstead; however, a farmer should be able to maintain the wiring as he would any other equipment.

No one would think of stepping in front of a tractor and push against it to stop it, yet it is not uncommon to hear of people picking up "hot" wires or touching "live" connections--carrying more potential horsepower; either action could be fatal.

This bulletin, which is approved by the Electrical Inspection Branch, Department of Industries and Labor, cannot replace years of study and experience but is published as a guide to help in the safe and efficient operation and maintenance of electric power on the farm.

Rural electrification is spreading at a fast pace and in a very few years all but a few farmers in outlying areas will have the opportunity of using electricity. Farmers requesting electrification form an Association under the Co-operative Activities Branch of the Department of Industries and Labor. Financial assistance is available from the Alberta Government. The Power Companies agree to build the line at cost.

A monthly service charge is made by the Power Company, for which they do the billing and collecting, and maintain the line. Part of their service charge is deposited to a depreciation fund and draws interest at 3½%, and may be refunded in part to the members if a surplus accumulates.

A permit must be obtained from the Electrical Inspection Branch, Department of Industries and Labor, Administration Building, Edmonton, to cover any new wiring or to make any addition to present wiring. If the owner of the farm wishes to do the wiring himself, the procedure is to write to the above, outlining the work to be done and requesting a permit; full instructions for filling out the permit will be returned, together with a pamphlet entitled "Regulations Governing Interior and Farm Wiring". This pamphlet outlines the methods to be followed in order to ensure a

safe electrical installation on farms or in other buildings in rural areas. If an electrician is to be employed to do the wiring, he will be responsible for obtaining the covering permit.

It is most important to make sure that this permit is obtained in all cases. It will ensure that the work done is inspected and meets the minimum safety requirements, and in the case of a new service connection, the permit is the authority for the power company to supply the installation. The power company will not make a new connection until the white copy of the approved permit has been submitted to them.

GENERAL INFORMATION

Electrical Terms

Electricity uses many terms that are not familiar to many, therefore a few definitions are given below:

Conductor	-	any material that will let electricity pass through it, e.g. copper wire.
Insulator	-	any material that will NOT let electricity pass through it, e.g. rubber or glass.
Volt	-	unit of pressure required to cause a flow of electricity.
Ampere	-	rate of flow of electricity--commonly called amp or amps.
Watt	-	measurement of electrical power (1 volt x 1 amp = 1 watt) or volts x amps = watts.
Kilowatt	-	one thousand watts.
Kilowatt hour	-	1,000 watts for an hour--Kwh.
Horsepower	-	1 h.p. = 746 watts.
Resistance	-	the opposition offered by a conductor to the flow of electricity through it. Resistance is measured in ohms.
Potential	-	voltage of a point with reference to ground.
Neutral	-	the current carrying wire at ground potential.
Electrode	-	either of the two terminals of a source of electricity.
Ground wire	-	any non-current carrying conductor connected directly to the earth by means of a rod or electrode.
"Hot" or "Live"	-	any wire connected to a voltage--usually meaning the wire carrying the transformer voltage.
Transformer	-	a device for changing alternating current to a higher or lower voltage.

KVA - Kilovolt amperes--used to rate transformer capacity.

Efficiency - output divided by input--usually as $\frac{\text{output}}{\text{input}} \times 100 = \%$ efficiency.

Frequency - number of cycles per second of alternating current.

RW - rubber covered waterproof.

TW - thermoplastic covered waterproof.

BXL - armour covered lead sheathed cable.

S.E.C. - Service entrance cable.

"Tub" - box housing breakers or fuses.

N.E.M.A. - National Electrical Manufacturers Association.

C.S.A. - Canadian Standards Association.

Direct Current - commonly called D-C, is current that flows in one direction only in a closed circuit and will have a definite positive and negative terminal. This type of current cannot be transformed and is, therefore, only used to electrify confined areas by local generators.

Alternating Current-commonly called A-C, is electricity that changes from zero voltage to positive to zero to negative and back to zero. This occurs sixty times per second in 60 cycle alternating current. The A-C reaches a maximum of approximately 160 volts and gives an average voltage of about 115 volts, and is actually at zero 120 times every second.

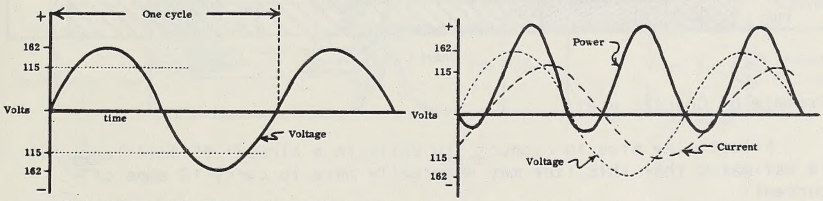


Fig. 1 ALTERNATING CURRENT

The description above is of single-phase power; however, two or three of these waves can pass along a circuit beginning at different times or one-third of a cycle apart. The terms polyphase (many phase) or three-phase are used to describe this type of power; however, it is only supplied to towns for industry and will not be discussed further. Single-phase power is all that is transmitted on rural lines, and may be taken out on one or two lines, depending on distances and voltages.

Voltage Drop

If too much current flows through a wire, the resistance will cause heat and will result in a lower voltage at the output of the line than the voltage applied at the input. To prevent excessive voltage drop and dangerous heating of conductors, the correct size of wire should be used. Selection of wire size is made on the basis of the length of line and the amount of current carried. Chart 1 gives this information.

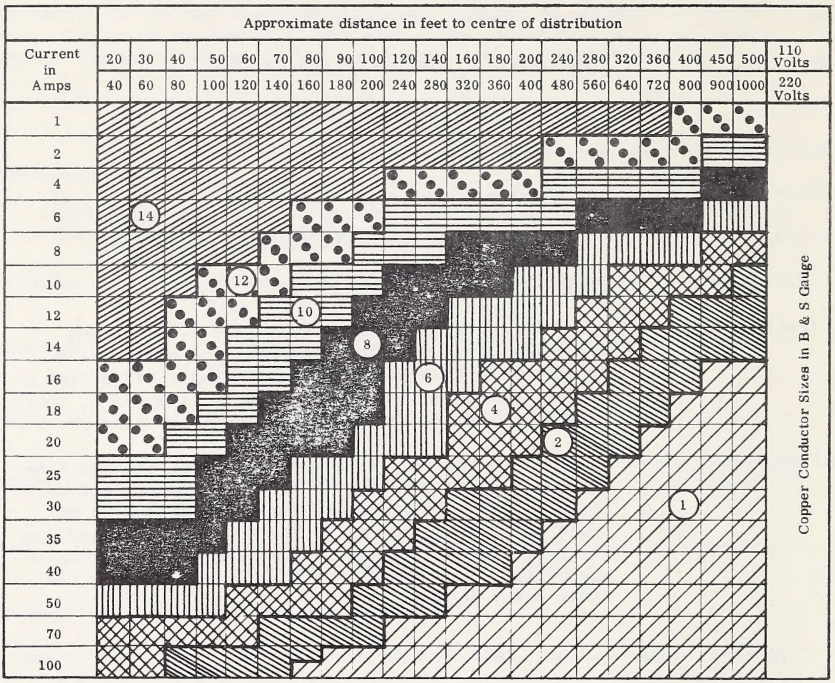


Chart 1

Example of Chart 1 use:

Select wire size to conduct 110 volts in a circuit 65 feet long. It is estimated that this line may eventually have to carry 12 amps of current.

Using the chart, the voltage is selected (top right-hand corner) and because 110 volts are being used, the top table of distances is used. On this table 65 ft. is not given, so the next larger number is used. Following the 70 ft. column down until the 12 amp current line is reached, it is found that the wire size "square" falls in the #10 bracket. This means #10 wire should be used for this circuit.

Note: In selecting the wire size for a circuit a check must always be made to determine that the conductors supplying power to the new circuit are large enough to carry both the existing and new load.

Transmission of Power

The common rural distribution lines carry 7,620 or 13,800 volts. The system of transmission may be either two-wire or single-wire but the latter can only be used where certain specific conditions can be met. Transformers are used to step the voltage up and down as required and are installed at the plants, sub-stations and finally in the yard for voltage outputs of 115 and 230 volts.

Transformers

A change of direction of current creates a magnetic field around a wire, and conversely, lines of flux cutting a wire generate a voltage. This constant changing which takes place with A-C current makes possible the use of a transformer. As the voltage and current change in the input winding, the field is carried by the iron cone to the secondary winding--the input voltage and the ratio of turns between the primary and secondary determine the voltage output. The secondary winding, producing 230 volts, is tapped in the center, which gives 115 volts between the center tap and either end (see Fig. 2). This center tap is connected to a good ground and is the neutral line of the system. These voltages are reasonably safe when proper precautions are taken in handling. It is estimated that 60 volts or 0.015 amps can kill humans, and somewhat less for animals, and many people die yearly from 110 or 115 volt shocks.

If 10 amps are being used across X and 6 amps on a circuit across Y (Fig. 2) then the current going through the neutral will be 10 - 6, or 4 amps. This is why S.E.C. is normally made with the neutral wire one size smaller, e.g. two #6 wires and #8 neutral.

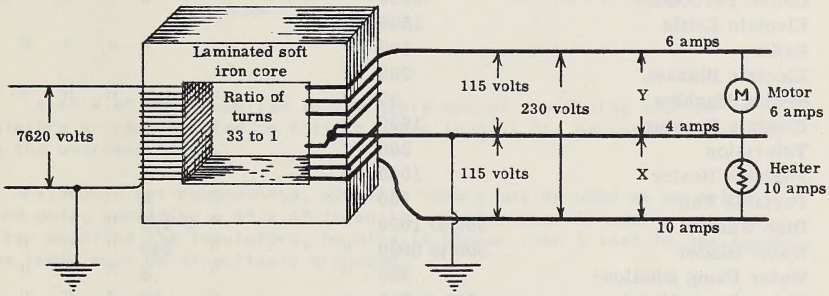


Fig. 2 A.C. Transformer, showing the input and output windings, and two schematic circuits to show the necessity of balancing the loads.

It is also important for operating efficiency to balance the load equally on both sides of the neutral; each side has a circuit breaker to protect the transformer. These breakers are tied together so that both lines are cleared if the breaker trips due to an overload on one circuit. Many farmers have changed from 3 to 5 KVA transformers when this expense could have been saved by balancing the 115 volt circuits. A 3 KVA transformer fused at 25 amps can deliver more than 5 Kwh continually and at over 7,000 watts per hour for short periods.

PLANNING FARMSTEAD ELECTRIFICATION

The transformer pole should be placed as close as conveniently possible to the center of load. The house and workshop are normally the largest consumers of power, but the danger of having the "high line" passing over driveways or roads should also be considered.

Size of wire used, whether underground or overhead, is an important part of planning, and consumption in future years must be anticipated. Refer to wire size chart 1, and also the chart 2 giving the consumption of some typical appliances.

COST OF APPLIANCES

Formula - $\frac{\text{watts x hours}}{1000}$ x rate = cost per hour.

CONSUMPTION OF HOUSEHOLD APPLIANCES

Automatic Toaster	1500	watts	approx.	3	kwh	per month
Refrigerator	250	"	"	35	"	" "
Hand Iron	1000	"	"	5	"	" "
Vacuum Cleaner	125	"	"	2	"	" "
Clock	30	"	"	2	"	" "
Range	1000 to 10000	"	"	120	"	" "
Ironer	1500	"	"	10	"	" "
Washing Machine	330	"	"	2	"	" "
Food Mixer	150	"				
Waffle Iron or Grill	1000	"	"	2	"	" "
Coffee Percolator	1000	"	"	5	"	" "
Electric Kettle	1500	"				
Radio	100	"	"	8	"	" "
Electric Blanket	200	"				
Sewing Machine	50	"	"	1/2	"	" "
Electric Roaster	1500	"				
Television	200	"				
Portable Heater	1000	"				
Portable Fan	100	"	"	2	"	" "
Dish Washer	500 to 1000	"	"	2-1/2	"	" "
Water Heater	500 to 3000	"	"	240	"	" "
Water Pump (shallow)	350	"	"	8	"	" "
Water Pump (deep)	500 to 750	"	"	10	"	" "
Heat Lamp	250	"				
Clothes Drier	1500 to 3000	"				

Chart 2

Overhead Wiring

Overhead wires of the weatherproof type must maintain a clearance of 14-16-18 feet, depending upon the type of traffic under the span. Spans must be limited to 100 feet for #10 B & S gauge wire and 125 feet for #8 B & S or larger. The poles must be at least 25 feet long with 5 feet in the ground and a top of at least 4½ inch diameter, and must be guyed at

corners or dead ends. Wires running horizontally must have an 8 inch clearance between them with the neutral in the top position. Wires may be brought to a building at 9 feet above ground, providing they approach at a steep angle and are not over areas subject to traffic. The wires must be anchored to the poles or buildings with approved secondary racks or service insulators (see Fig. 3). Insulators or racks must not be anchored to the shingles or top covering of a roof. Electrical wires must not be less than 8 feet vertically over any roof flat enough to allow a person to stand on it, and must not be less than 3 feet vertically from any roof with a steeper slope. Drip loops shall be formed on individual conductors. Wires and connectors are to be taped. Wires may be soldered and taped instead of using connectors as shown.

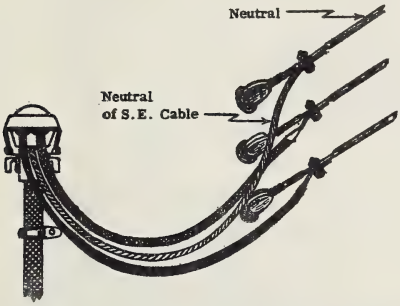
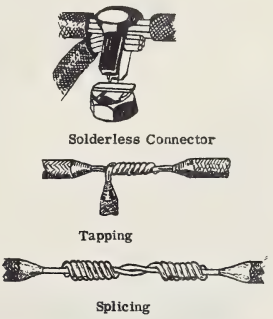


Fig. 3 How to Connect Wires From Entrance Head to Overhead Wires



Connecting to and splicing overhead wiring.

A 4" x 4" may be bolted to the gable end of a building and the insulators or rack mounted on this in order to give the necessary clearance to the overhead lines.

Although not recommended, windmill towers may be used as an extra yard pole, providing a 4" x 4" is bolted to the tower in such a way that after mounting the insulators, no wire is closer than 3 feet to the tower. The tower must be effectively grounded.

Underground Wiring

Several types of wire may be used, including RW or TW, BXL or just lead sheathed cable. The TW is more commonly used as it is serviceable and reasonable in price. The wires should be laid at the bottom of a trench at least 18 inches deep and with a smooth bottom. It is suggested that an inch or two of sand or fine dirt be put in the trench before laying the wires. The wires are laid in loosely--about 1 foot slack in 25 feet, and covered with sand or fine soil, then a creosoted plank or board is placed over the sand and wire for mechanical protection. An alternate method is to run the TW or RW conductor through a non-metallic pipe such as plastic pipe, which is to be one size larger than the conduit.

An adaptor for metal to plastic pipe is to be used and the plastic pipe is also to be laid in loose dirt or sand. Under roadways carrying heavy traffic, the wires must be buried at least 3 feet and provided with protection as above, or they may be run in conduit. Splices or junctions shall not be made underground but only at junction boxes at buildings or stub poles, the junction boxes to be at least 3 feet above ground. The wires must be run in conduit from the bottom of the trench to the junction box, service entrance panel, etc. (see Fig. 4). Bushings should always be used in the end of any conduit to avoid damage to the entering wires.

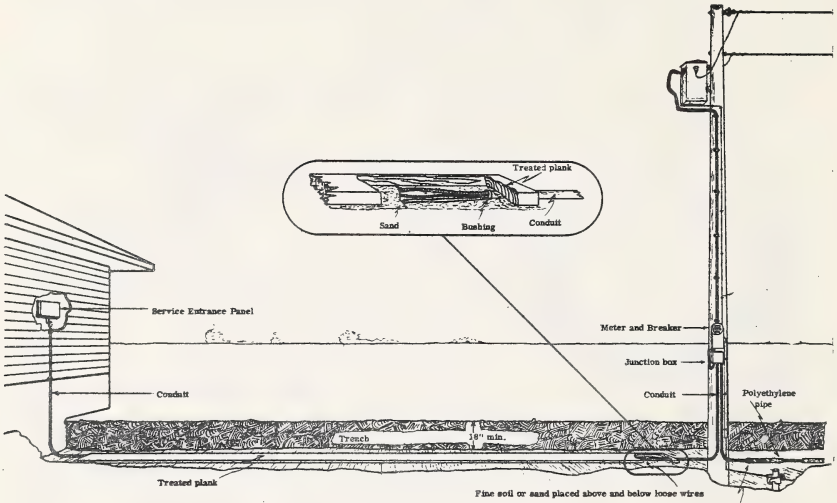


Fig. 4 Underground installation using TW or RW insulated conductors

TW or any other plastic covered wire should not be handled or installed below freezing temperatures due to the danger of cracking the insulation, which may cause leakage of power or a direct short.

Any underground installation should be considered a permanent installation and should be installed as such--carefully, correctly and in a workmanship-like manner.

Advantages

Overhead

Speed of installation.
Ease of repair.

Underground

No danger of collision with traffic.
No danger from ice or wind storms.
Wires can be run around corners, through windbreaks, etc.
Appearance.
More permanent.

Disadvantages

Chance of collision & personal injury.
Can be broken by ice and wind.
Poles depreciate.
Trees must be trimmed.
Unsightly.
Difficult to repair, if necessary.
Slower installation.
Installation can only be done in frost-free weather.

Information gathered recently shows the difference between the cost of construction of overhead and underground systems on average farms is negligible. The type of wire used can vary this cost considerably.

Service Entrance Panel

In houses, this should be installed in an accessible location--preferably in the kitchen, hallway or entrance landing. The panel shall not be installed over stairs and must be between 5 and 7 feet from the floor.

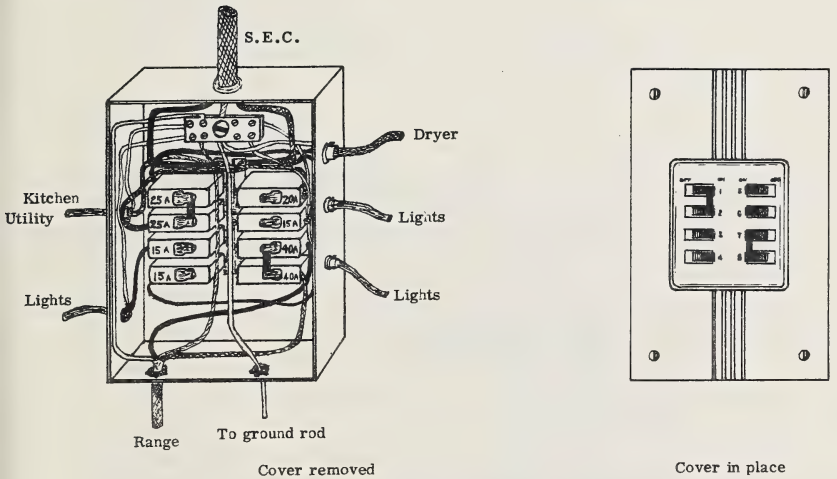


Fig. 5 Service Entrance Panel

Buildings which are always dry may have the service panel installed inside the building, but buildings housing livestock, which create moisture and condensation during cold weather, must have the service panel outside in a separate weatherproof cabinet or in a separate room in a dry, but not dusty, location. In barns a flush installation may be obtained if a portion of the studding is sealed off from the inside and the panel installed facing out (see Fig. 6). If circuit breakers are used in these panels they must be of the thermal-magnetic type in order to give ample protection to the circuits in cold weather.

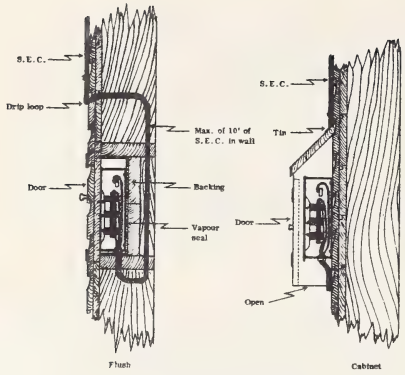


Fig. 6 Typical circuit breaker panel installations. Panels 5 to 7 feet from ground level.

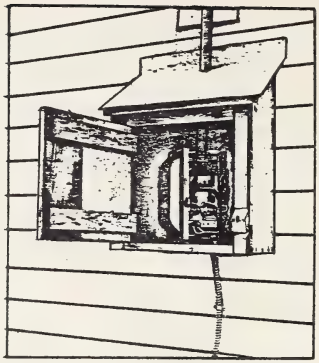


Fig. 7 Combination Fuse Panel & disconnect switch in a cabinet installation.

Circuit breakers are becoming very popular and have the following advantages over fuses:

1. It is impossible to tamper with circuit breakers.

2. They will take a momentary overload without tripping--useful on motor circuits, etc.

3. No part of the circuit breaker is ruined or has to be replaced after tripping.

4. A disconnect switch does not have to be installed ahead of the circuit breaker on farms since a main service disconnect is provided by the main breaker on the transformer pole.

If the present panel is too small, a second may be installed beside it.

Fuses of the correct rating give good protection. They must be preceded by a disconnect switch except for particular cases as outlined in the Regulations Governing Interior and Farm Wiring. One shortcoming of fuses is the ease with which they can be "slugged" with pennies, or wrapped with tinfoil, which completely destroys any protection for the circuit.

SERVICE ENTRANCE CABLE

Wire Size (B & S)	Maximum Allowable Current (amperes)
No. 10	30
No. 8	40
No. 6	55
No. 4	70
No. 2	100

Chart 3

If the circuits are increased, the available output is increased and the service entrance cable may have to be increased in size and probably the wires leading from the transformer will have to be changed to larger sizes. Different capacity panels require different sizes of service entrance cable.

Service entrance cable, or S.E.C. as it is more commonly referred to, is the two or three wire conductor used to bring the power from the overhead lines to the service entrance panel. It is weatherproof and the metal plaid or sheath covering the one or two insulated conductors gives the cable added strength and mechanical protection; at the same time it acts as the neutral wire when twisted together to make a stranded wire (see Figs. 9 & 3). When the S.E.C. is connected to overhead wires, always leave plenty of length from the service entrance cap so that a drip-loop is formed, making it impossible for water to run inside the S.E.C. If the S.E.C. is installed before the overhead lines, at least 30 inches must be left from the service entrance cap to allow for making drip-loops (see Fig. 3). These connections to the overhead lines should be tightly twisted and clamped with a Servitt connector and taped, or soldered and taped if preferred. S.E.C. must terminate in an approved service entrance switch or circuit breaker within 10 feet of entering the building structure.

Grounding

The "tub" must be bonded to the neutral block and a continuous wire of #8 B & S must run from the neutral block directly to an approved ground rod, which must be an 8 foot rod or pipe at least ½ inch in diameter, driven one foot below ground level and the wire connected to this by means of an approved ground clamp. The ground wire should be protected from mechanical injury--if metal clad with BX, etc. the armour must also be clamped to the rod.

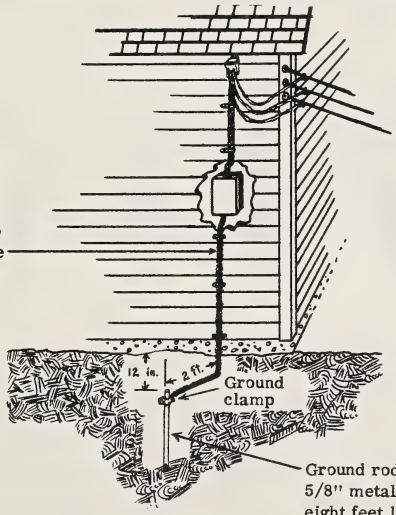

No. 8 ground wire connected to neutral bar on service entrance panel. To be protected from mechanical injury.
12 in.
2 ft.
Ground clamp
Ground rod, 3/4" pipe or 5/8" metal rod not less than eight feet long.

Fig. 8 Grounding the service entrance panel.

If a building is equipped with lightning rods and electrical wiring, the two systems should be kept at least 6 feet apart at all points, including ground electrodes. Where the two systems approach each other closer than 6 feet at any point, the ground electrodes must be bonded together at or below ground level with a conductor not smaller than No. 6, and the ground rods not less than 6 feet apart. The person making the last installation is responsible for carrying out this work.

Telephone, radio or T.V. grounds, together with those of the lightning or electrical systems, should all be separated by at least 6 feet.

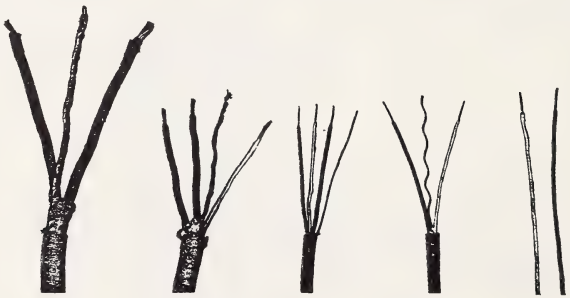
TYPES OF INTERIOR WIRING

Non-Metallic Sheathed Cable - is now commonly used for wiring where there are no explosive gases or danger from mechanical injury. In damp locations acid resistant, plastic covered, non-metallic sheathed cable MUST be used. Where a non-metallic wiring system is used, a ground connection shall be provided at all outlets and metallic boxes shall be grounded.

Rigid Conduit - must be used in buildings where explosive gases or dust are present, also in buildings of other than wood construction.

Thin-Wall Conduit - used in buildings of other than wood construction where explosive gases or dust are not present.

Knob-and-Tube Wiring - This is practically an obsolete form of wiring but may still be used if desired. It is usually expensive due to the labour required in installation.



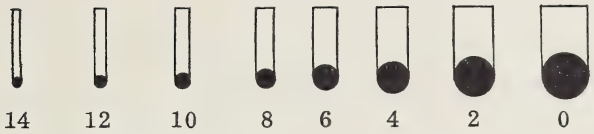
A. Service Entrance Cable (S.E.C.)
B. Range cable
C. Three conductor non-metallic sheathed cable with ground conductor
D. Two conductor non-metallic sheathed cable with ground conductor
E. Thermoplastic wire (T.W.)

Actual diameters of different sizes of wire, without insulation

Fig. 9a Wire sizes.

The above methods of wiring will all pass inspection if installed correctly in the appropriate type of building. Other types of interior wiring, such as BX (armoured cable), are now not allowed except in short lengths where it is exposed, normally for furnace and motor controls on metal surfaces. BXL is an acceptable type of wiring.

This bulletin will deal only with wiring with non-metallic sheathed cable, which covers the majority of farm wiring.

Switching

Wall switches should be located at a convenient distance from the floor level and from doorways and entrances in the house and farm buildings.

Two-Way Switching

This is the standard system used in most circuits when a circuit is opened or closed from one location. For silent operation, mercury switches may be used in place of the standard mechanical toggle switch.

Three-Way and Four-Way Switching

Three-way switching is used where it is desirable to control an outlet or circuit from two points, such as a stairway, where the light can be switched on or off at both the bottom and top of the stairs. If switching at more than two points is required, any number of four-way switches may be connected into the circuit between the two three-way switches to give the additional control points. An example would be a long barn, where switches at both doors, as well as near the center of the building, would be advantageous.

PLANNING WIRING IN FARM BUILDINGS

House - The importance of adequate wiring which will take care of future as well as present requirements, should be emphasized. Usually the average farm home will require a 100 amp service, i.e. a panel housing 12 breakers.

Kitchen. This room is usually used more than any other, and therefore should be well lighted. The receptacles for plugs are connected by what is commonly called the "kitchen circuit". This circuit must be

wired with #12 or larger wire, fused at 20 amps, and can contain only 4 outlets (one outlet consists of a receptacle able to hold two plug caps at once). If more than 4 outlets are required in the kitchen, then another similar circuit must be used and fused separately at the panel. If outlets for pantry, utility rooms or laundry room are to be used for the supply of appliances, they may be included in the kitchen circuit, providing the total is kept to 4 outlets per circuit. That is, they must be on a utility circuit.

The receptacles on the kitchen circuits must all be of the grounded or N.E.M.A. type (see Fig. 10). Standard two prong plugs may also be used in a N.E.M.A. receptacle. If the outlets in the kitchen, being used for appliances, are not of the grounded type, they may be replaced by the N.E.M.A. type receptacle and a ground wire run to the ground terminal at the service entrance panel. This grounded outlet and plug is designed to improve electrical safety.

When planning the kitchen lighting circuits, one should consider such conveniences as exhaust fans over the range, outlet for an electric clock or radio, sink lights, etc. The outlets just mentioned are considered to be out of reach from the floor and, therefore, not required to be part of the kitchen utility circuit previously mentioned, and do not require N.E.M.A. receptacles.

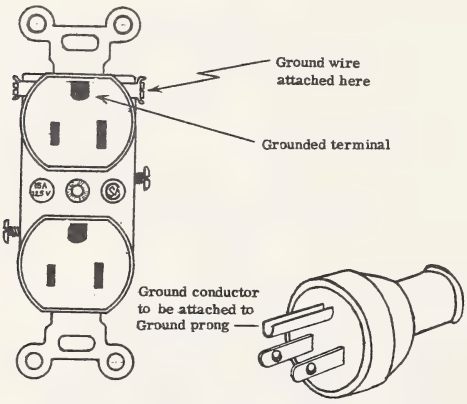


Fig. 10 NEMA type grounded duplex receptacle and plug.

Fig. 11 Dust proof holder and shield.

Outlets are usually between 36 and 42 inches from the floor. They must not be placed inside any cupboard. If an electric range is to be installed, a separate 230 volt circuit must be installed for this unit, using "range cable" or service entrance cable.

Living and Dining Rooms. Receptacles and lighting outlets may be connected to the same circuit, providing the total number of outlets does not exceed 8 and the total power requirement is not more than 1,500 watts. Special appliances using over 1,500 watts, such as some electric heating fireplaces, shall be on a separate circuit. For convenience it is suggested that a receptacle be provided for at least each 12 feet of wall length, and on long wall sections these outlets should be near the ends of the wall.

Basement. Lamps which light the basement stairs shall be controlled by a switch located at a convenient point above the stairs, so that the stairs are illuminated before entering the basement. Any light fixtures less than 7 feet above the floor must be free to swing or be protected from mechanical injury. Rigid fixtures may be used above this height. Receptacles for the supply of appliances must be of the grounded (N.E.M.A.) type and separate circuits supplied for furnace controls or water pressure systems carrying motors. Special appliances rated over 1,500 watts and motors over 1/3 h.p. shall be placed on a separate circuit.

When metal boxes are used in the basement they must be grounded. Grounding of boxes and receptacles can be easily done by using a two-wire-with-ground type of non-metallic sheathed cable--in this the bare copper wire is the ground, white neutral, and black is the hot wire (see Fig.9 D).

Thought should be given to the installation of an automatic sump pump in the basement of the farm home.

Bathroom. Plug receptacles or combination lighting and plug receptacles shall not be installed in rooms where there is a bathtub or shower. An approved combination isolating transformer and electric shaver receptacle may be installed in the bathroom for the use of an electric razor only. The bathroom light receptacle must be out of reach. Drop lights shall not be used in this location except where the ceiling is 7 feet or less in height, and the lamp holder must be insulated and grounded and must be switched by a wall switch, preferably near the door. Heaters or any other appliance may be built into the wall and switched on the wall, provided they are effectively grounded, but must not be used on an extension cord.

Exterior. It is suggested that consideration be given to the installation of a weatherproof plug receptacle outside the front or back door for plugging in a car, block heater, power appliance or Christmas lights, etc. Such receptacles are to be the grounded N.E.M.A. type.

Bedroom. Plan for an adequate number of receptacles, preferably near the corners rather than in the middle of the walls.

Clothes Closets. A light inside and above the door on a pull chain or door switch is a convenience often overlooked.

Stairs and Hallways. Three-way switches at the bottom and top of the stairs or in hallways are often very convenient.

Livestock Buildings - These are considered to be damp locations, and the fumes from the manure corrode metal parts quite quickly. Plastic or bakelite boxes and non-metallic sheathed cable with moisture proof, acid resistant outer cover, and individual conductors insulated with TW or RW, must be used in these locations. Lights shall be free to swing on a pig-tail socket (non-metallic) if below 8 feet; above 8 feet, porcelain sockets may be used for solid lights.

When installing milking machines, care must be taken to ensure the motor and pump are safely and adequately grounded. The vacuum pipes must also be bonded to the vacuum pump and motor and thence to ground.

Consideration should be given to the use of ultra-violet, bactericidal lamps which may be useful in controlling mastitis or poultry diseases, etc.

Heat Lamps. Portable heat lamp installations should be made as follows:

1. The receptacle must be of the grounded type.

2. The cord must be of a high grade, rubber covered, asbestos insulated type, such as HSJ, and not more than 8 feet long.

3. Only heat resistant procelain lamp sockets shall be used--NOT rubber.

4. The lamp or lamps shall be protected by a non-removable guard mounted to a reflector type top and the unit suspended by a chain or cable--NOT by the cord.

5. The guard assembly must be grounded back to the receptacle.

Dusty Locations. The hay loft, feed room and granaries are typical dusty locations, and must be illuminated with a light in a dust-proof holder and shield (see Fig. 11). Switches for these lights should be installed outside the building or room, or be of an explosive-proof type.

Workshop - This building requires special consideration because of the variety of electrical hand tools and machines used there. Therefore, it is important that the receptacles (115 and 230 volts) be of the grounded type. Where both 115 volt and 230 volt receptacles are installed in the same premises, the receptacles used in the outlets supplied at 230 volts shall be so constructed that standard 115 volt plugs cannot be inserted. Size of wire, both to the building and within the building, should be planned carefully and be large enough to carry future as well as existing loads. A separate panel and service entrance may be installed for a welder. Adequate workshop lighting is important in areas where detailed work is to be done.

MOTORS

The three common types of motors used on the farm are the split-phase, capacitor and repulsion-induction. The universal type of motor is also quite common in hand tools and appliances but is not usually bought as a replacement motor on the farm. All of these motors use single-phase power of 60 cycle frequency as supplied to rural areas. Three phase motors cannot be used unless expensive alterations are made to the system. One-quarter horse power motors are usually operated on 115 volts, 1/3 h.p. motors may be used on either 115 or 230 volts, and ½ or larger h.p. motors are recommended for use on 230 volts only. The three types of motors mentioned here derive their name from their starting mechanisms and characteristics; they generally have four pole stators which gives them a theoretical speed of 1,800 r.p.m. but with the "slip", which is a normal and variable characteristic of motors, the actual r.p.m. is about 1,725.

Special motors may be purchased to operate at various speeds, also various types such as explosion proof, totally enclosed, syncronous and many others. Only the three common types will be discussed here.

Split-Phase - This is the simplest type of motor, having no brushes nor commutator. This motor requires a very high starting current and has a low starting torque, but it will maintain its full rated h.p. after it reaches operating speed. It will NOT start heavy loads. Generally these motors are only made in sizes up to 1/3 h.p.

Capacitor - This motor is very similar to the split-phase type except that a condenser is put in series with the starting winding. This enables it to start much heavier loads, even though it uses only half of the starting current of the split-phase unit. This type of motor can be made in any size but is generally produced in the ¼ to 1 h.p. range. It is commonly used on water pressure systems, compressors, and other loads that require a high starting torque.

Repulsion-Induction - This is a heavy duty type of motor which has the ability to start heavy loads. It has an armature type of rotor and brushes, and by these and the general shape of the frame, can usually be recognized. The starting current required is less than with other types, while starting torque is about 3.5 times running torque. It is comparable to the capacitor motor in characteristics, but generally cheaper in sizes over 3/4 h.p. This is the type used for grinders, hammer mills, and other heavy loads.

Overcurrent Protection

When a motor is started it will draw from 3 to 5 times its normal running current, depending largely on the load it is starting. Therefore, the circuit must be fused to carry that high current. Circuit breakers are preferred because they will stand momentary surges of current and not cut out.

Overload Protection

A good motor will stand a 50% overload for a considerable time without burning out, but this is not recommended. To prevent excessive heating of the motor due to overloading, a thermal breaker type of switch is installed. The heater element for this unit is made in various sizes and must be selected for motor current and type of operation. For manually switched motors the heater element should be rated at 125% of the motor nameplate current rating. For automatically switched units the heater rating is increased to 140% of nameplate current rating. Because of the time delay in the heater reaching trip-out temperature, the current surge for starting does not trip the overload protector.

Example: Consider a 1/3 h.p. motor with nameplate rating 5.6 amps on 115 volts, manually switched. The motor protection switch should be equipped with a heater rated at 125% of 5.6 amps (i.e. 7.0 amps). If the above motor were operated with an automatic switch, the heater in the overload protection switch should be rated for 140% of 5.6, or 7.8 amps. With this particular example a 20 amp fuse may blow when the motor starts but a 15 amp breaker in the service entrance panel would carry the extra surge of power required--neither would protect the motor from burning out if the protection switch were not in the circuit.

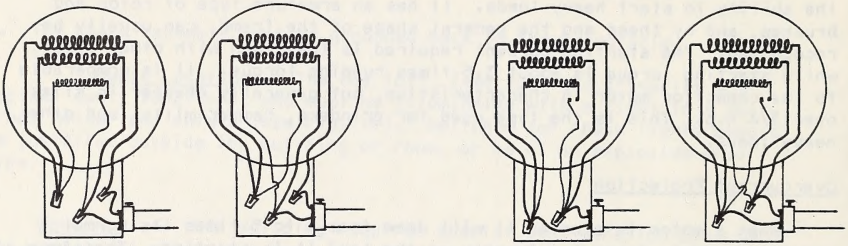
Motor protection switches used on 230 volts must break both hot lines.

Connecting on 115 or 230

The nameplate will show whether a motor can be used on either voltage or only one. When motors are used on 115 volts the running windings and starting winding are in parallel. On 230 volts the running windings are in series and the starting winding is in parallel with one-half of the running winding. This is shown in Fig. 19.

Reversing Direction of Rotation

With split-phase and capacitor motors, this is accomplished by reversing the starting winding in relation to the running winding as shown in Fig. 12. With repulsion-induction motors, there is usually a means of rotating the brushes which will reverse the direction.



230 volt connections

115 volt connections

Note: Starting switch open or in full speed operation.

Fig. 12 Reversing direction of rotation of an electric motor by changing the starting winding connections.

Motor Bearings

Many of the modern motors have "life-time" bearings which require no care or lubrication; these are usually factory-packed ball bearings. In extremely cold weather this type of bearing may become stiff as the grease hardens, and some difficulty in starting may be encountered. Ball bearings which require oiling should be lubricated with only two or three drops of light oil every 500 hours of use. The ball bearing motor is preferable where there is end thrust on the shaft, either from loading or position of motor. For light duty machines, the sleeve type bearings in the motor are quite satisfactory and should be lubricated as above.

Pulley Sizes and Shaft Speeds

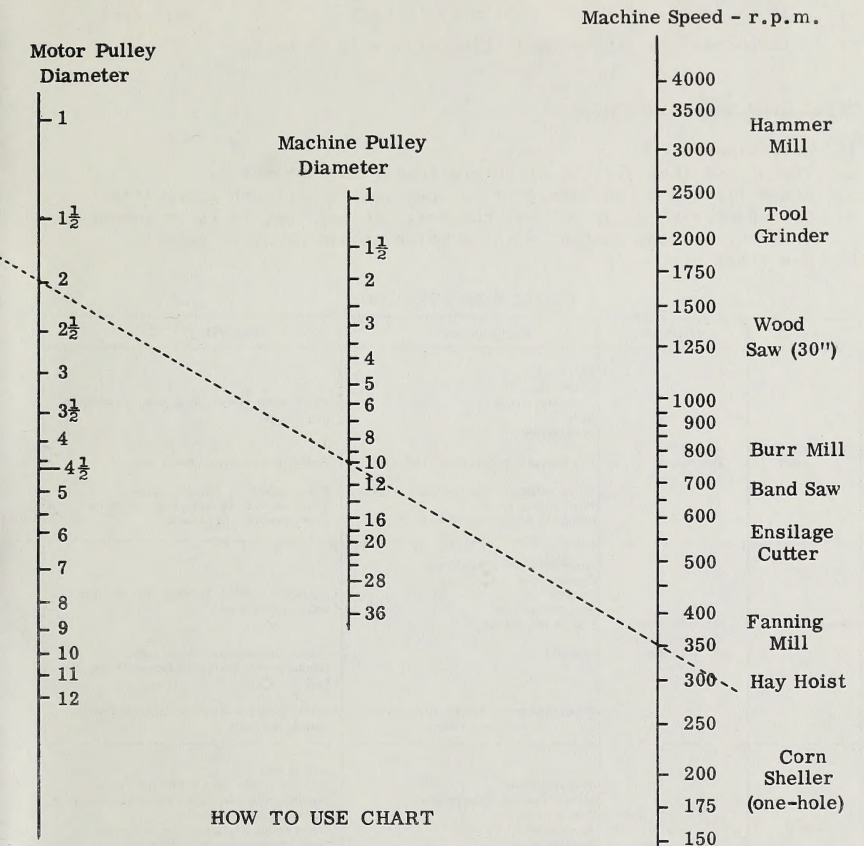
In any pulley and belt hook-up there are four factors, two pulley sizes and two shaft speeds. If three of these factors are known, the fourth can be determined from chart 4. It may also be calculated from the formula:

Motor pulley diameter x motor shaft r.p.m. = machine pulley diameter x machine shaft r.p.m.

Example:

Motor pulley diameter	-	to be determined (X)
Motor shaft r.p.m.	-	1,725
Machine pulley diameter	-	6 inches
Machine speed	-	575 r.p.m.

PULLEY SELECTION CHART FOR USE WITH ELECTRIC MOTORS RUNNING AT 1725 REVOLUTIONS PER MINUTE



HOW TO USE CHART

Lay a straight edge across the chart between any two of the three factors represented by the vertical lines. Read the desired information where the straight edge crosses the third line. If you have pulleys for motor and machine, connect the points on the lines indicating the pulley diameters, and read the resulting machine speed on the third line. Or, if you want to know what size pulleys will be required to obtain a specified machine speed, lay the straight edge across the right-hand line at the point indicating the speed. Slide the other end of the straight edge up or down. Wherever it crosses the other two lines you can read the combination of pulley sizes which will give that speed.

CHART 4

N.L.C. - B.N.C.
3 3286 10643329 1

Solution:

(Motor pulley diam) (Motor rpm) = (Machine pulley diam) (Machine rpm)

or (X inches) (1725 rpm) = (6 inches) (575 rpm)

or (X inches) = $\frac{(6 \text{ inches})(575 \text{ rpm})}{(1725 \text{ rpm})} = 2 \text{ inches.}$

Motor Care and Maintenance

1. Keep clean.
2. Install so that air can circulate freely through motor.
3. Dismantle and clean yearly if in areas where dirt can accumulate.
4. Oil sparingly but do not let run dry. As a guide, it is recommended that the average washing machine motor should be oiled yearly.
5. Use light oil.

ELECTRIC MOTOR TROUBLE CHART

FAULT	SYMPTOM	POSSIBLE CAUSE	TREATMENT
Motor fails to start	Dead motor Motor hums	Line trouble Connections Protection device Fuse Open circuit	Check power circuit, fuse, switch, protection, and voltage
		Low voltage resulting from overloaded line	Reduce load or change power unit
		Worn, stuck, or improperly set brushes	Clean, adjust, or replace brushes
		Worn commutators	Clean, smooth, or redress commutators
		Burned or broken connections	Check windings and contacts
Slow starting	Excessive hum Slow to gain operating speed	Commutator and brush trouble Open circuits Grounds Poor connections High or low voltage	Check commutator, brushes, circuits, line voltage, wire sizes
		Overload	Reduce load; change pulleys; reduce belt tension to permit slippage during starting period
		Unbalanced rotor, rotor rubbing stator, or uneven air gap	Check spacing with feeler gauge and realign bearing and shaft
Overheating	Excessive temperature beyond manufacturer's operating recommendations	Overload Poor ventilation Exposure to high temperatures Poor lubrication Open circuits and ground Misalignment Excessive belt tension or end thrust Friction due to worn bearings or tight bearings	Reduce load Clean dust, dirt, gum and oil from motor Provide protection; supply additional ventilation Provide proper lubrication Check wiring diagram and power circuit Check rotor balance and alignment Reduce belt tension Clean, replace, or ream bearings
		Wrong brush grade or pressure	Adjust brush pressure and correct grade
Vibration	Noise Knocking Clicking	Vibration in driven machine Faulty drive Faulty belt, pulley, coupling or alignment	Disconnect motor to locate cause of vibration Align motor shaft with driven shaft Adjust belt tension; check pulley balance, check belts and couplings
		Unbalanced rotor Loose bearings Loose base Poor lubrication	Check rotor balance Replace bearings Check alignment and tighten base Provide proper lubrication
Commutator and brush trouble	Excessive sparking Arcing at the brushes Blackened commutator	Dirty or rough commutator Worn or stuck brushes	Sand or redress commutator Adjust brush pressure and use correct grade; clean brush holders and replace or reface glazed brushes
		Overload Open circuits or grounds Poor connections High or low voltage	Reduce load Check circuits and transformer capacity

CHART 5